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HIGH ALTITUDE SMOKE PROGRAM (HASP-II).(U)

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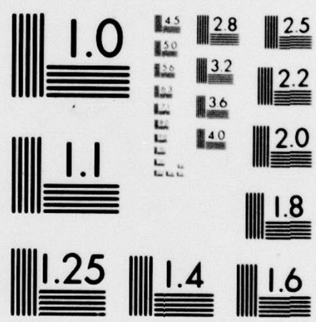

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AFGL-TR-79-0252

HIGH ALTITUDE SMOKE PROGRAM (HASP-II)

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Final Report
30 April 1979 - 30 September 1979

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AIR FORCE GEOPHYSICS LABORATORY
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A dispenser previously developed ~~under Contract No. F19628-77-C-0136~~ for high altitude (85,000 ft) release of smoke puffs in support of ~~Air Force Geophysics Lab~~ stratospheric turbulence studies was modified to incorporate direct thermal input to each launch tube. The modified dispenser was environmentally & functionally tested prior to delivery to Holloman AFB, N.M. for balloon test. The dispenser ejects six (6) smoke puff canisters containing equal weights of $TiCl_4$ & a 50/50 Water-Methanol mixture.

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1.0 INTRODUCTION

The objective of this contract was to modify smoke puff dispensers designed and developed under Contract No. F19628-77-C-0136 for high altitude (>85,000 ft.) release of smoke puffs in support of Air Force Geophysics Lab stratospheric turbulence studies. The dispensers provide environmental protection and sequentially eject six (6) smoke puff canisters containing equal weights of $TlCl_4$ and a water/methanol mixture. Each canister was designed to function 100 ft. below the balloon platform via a tethered lanyard. Barometric switches safe the system below 14,000 feet altitude and automatically eject any unexpended payloads upon descent below 30,000 feet. A cable cutter severed all lanyards after payload ejection to preclude potential interference for those missions which included airborne (helicopter) recovery.

Modifications to improve performance and reliability recommended in the previous contract final report (AFGL-TR-78-0147) entailed performing additional thermal testing and substituting pyrotechnic eject squibs and delay mechanisms for the tethered lanyard system. However, requirements for smoke puff release 100 $\pm$ 5 feet below the dispenser and to maintain a "quiet" dispense environment precluded using the pyrotechnic eject squibs and delay mechanisms. Modifications were therefore limited to incorporating direct thermal input to each launch tube and conducting complete ground environmental and functional testing to insure adequate performance. The program commenced on 30 April 1979 and the hardware was delivered approximately six (6) weeks later (13 June 1979) to Holloman AFB, New Mexico for flight test.

2.0 TECHNICAL APPRAOCH

2.1 Canister Design

The HYCOR technical approach to the smoke-puff canister design was to use the basic design developed under Contract No. F19628-77-C-0136. This design uses a chemically strengthened glass as the primary canister material. In addition to providing an excellent container for fluid payloads, this glass is extremely durable due to chemically produced compressive stresses in all external surfaces. Since glass only fails under tensile loading, these surface compressive stresses must be exceeded before fragmentation can occur. When pierced with a sharp, hard point, however, this glass exhibits a secondary unique characteristic in that the entire canister disintegrates instantaneously as equilibrium between the outer compressive stresses and internal tensile load is destroyed. Because of this latter characteristic, this pre-stressed glass is often referred to as frangible glass and the resulting canisters as frangible glass canisters. An additional feature which makes these frangible glass canisters attractive for this smoke puff application is the ability to contain two separated, reactive fluids within one canister via a sealed bulkhead. Upon total canister disintegration, fluid mixing occurs giving off smoke at the point of release below the balloon.

The HYCOR smoke puff canister design is shown in Figure 1. Note that a single 1.25" diameter x 6" long frangible glass canister has been divided into two sections containing equal weights of $TiCL_4$ and 50-50 H_2O/methanol mixture. The payload separator contains a hole for filling the lower section with methanol and water. The canister upper end-cap contains a spring loaded pinger assembly for initiating canister fragmentation. The pinger is prevented from moving by a restraint pin. This pin is attached to a 100 ft. braided tether line which is wrapped on a spool contained in the dispenser. After canister ejection from the dispenser, the tether line unravels from the spool over 100 ft. of descent and the pin is pulled. Total canister disintegration

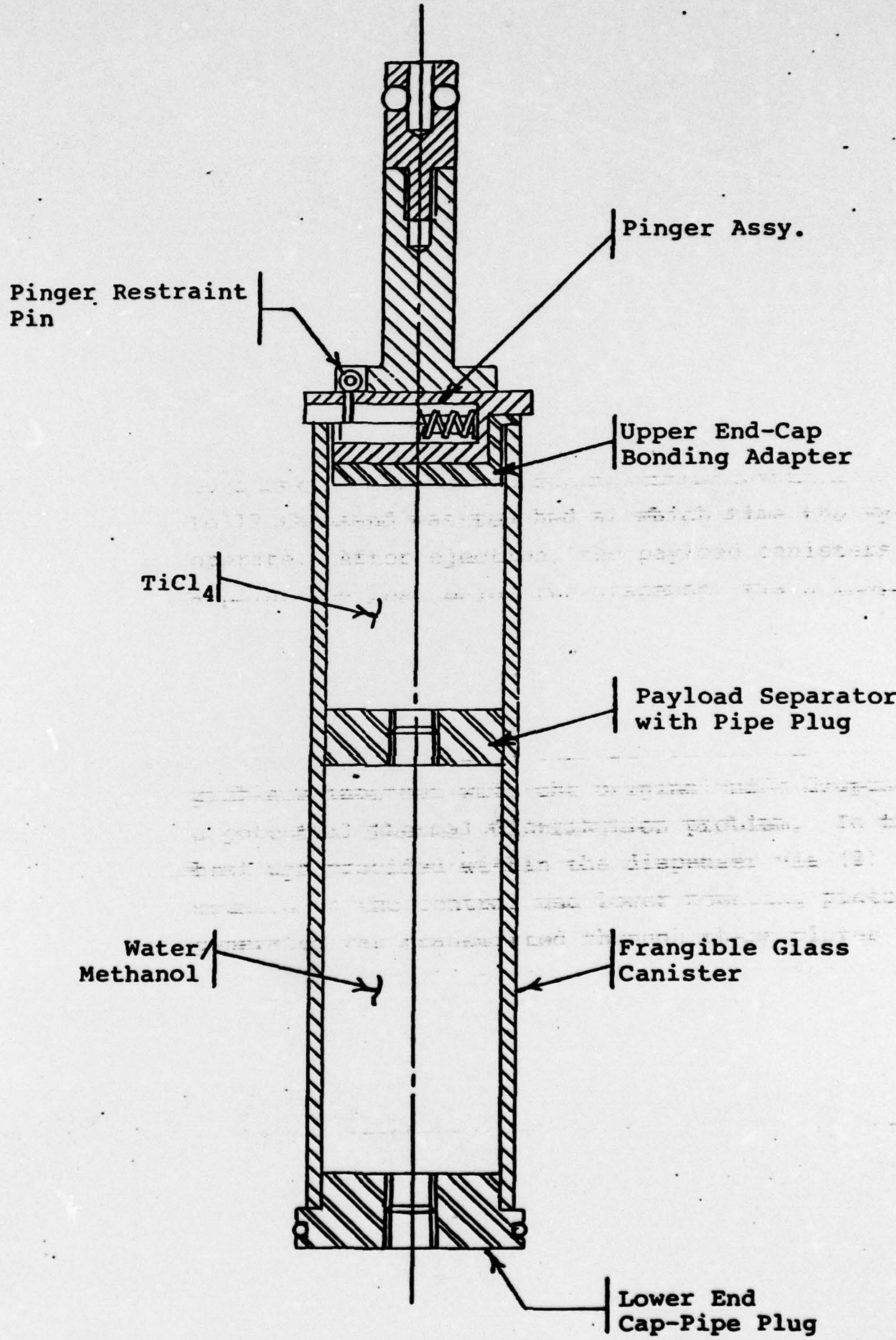

Figure 1. HYCOR SMOKE PUFF CANISTER-REFERENCE DESIGN

occurs instantaneously as the hard, sharp tipped pinger point penetrates the glass. This allows immediate interaction between the $TiCL_4$ and the methanol/water which results in the generation of the desired smoke puff. This sequence of events is depicted in Figure 2.

2.2 Dispenser System

The original HASP dispenser was a self-contained system that could be raised up to a high altitude by a balloon and would individually eject, upon command, six payload canisters containing smoke generating chemicals. The system was safed by a barometric switch during ascent until an altitude of 14 to 17 thousand was reached at which time the system was able to operate. After ejection, the payload canisters functioned at a point 100 feet below the dispenser via a lanyard. The system was designed to operate at altitudes in the area of 100,000 feet and contained sufficient power to have a mission time of 12 hours with temperatures as low as -65^{o}F.

A detailed analysis of the canister malfunction problems incurred with the original HASP dispenser pointed to a potential thermal distribution problem. In the original design, heat was provided within the dispenser via (8) 5 watt resistors mounted on the central and lower mounting plates. The heat generated was transmitted through these plates to the launch tubes via conduction. To reduce conduction of this heat to the outer case, fiberglass strips were placed between the plates and the outer case. Environmental testing (low temperature only-no altitude) indicated adequate performance. However, it was felt that extraneous heat paths may have occurred in flight at altitude which reduced the heat input to some of the launch tubes, thereby allowing freezing of the canister payloads. To solve this problem, the original HASP Dispenser was modified

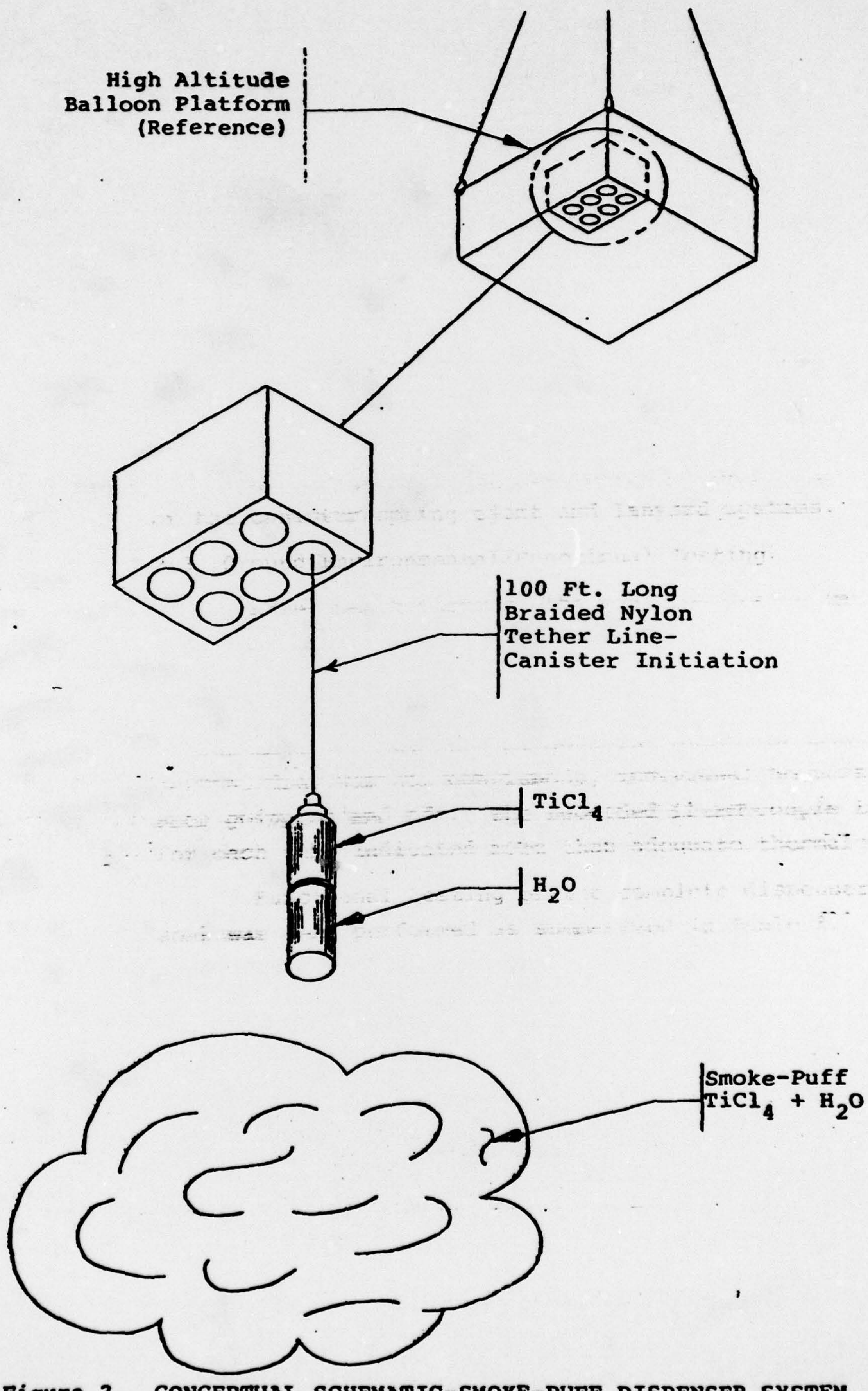

Figure 2. CONCEPTUAL SCHEMATIC-SMOKE-PUFF DISPENSER SYSTEM

to include a direct launch tube heating system. Individual flexible heaters were installed around each payload ejector tube. Thermostats were incorporated to regulate the heat to each tube and switches installed near each tube to cut the power flow to its heater after the payload was ejected.

To support the higher heating loads, more battery capacity was added. External storage of the additional batteries in the balloon gondola section was coordinated with the AFGL launch system design team. In addition, the dispenser assembly was placed in a styrofoam case.

No changes were made to the explosive bolt release system or the canister spring eject and lanyard systems.

2.3 Ground Environmental/Functional Testing

After bench testing, the modified design was thoroughly environmentally tested. The initial environmental test results are provided in Table 1. This test resulted in minimal current draw with the dispenser housed in the styrofoam case. Per Table 2, the test was repeated without the styrofoam case, and although current draw was not continuous, individual heaters could be seen going on and off. The recorded thermocouple temperatures for each tube indicated more than adequate thermal protection.

Functional testing of the complete dispenser after cold soak was next performed as summarized in Table 3. Six canisters were successfully functioned from a height of 70 ft. with 50 ft. lanyards. It should be noted that no canister tumbling was observed. Film data of this test was provided to AFGL.

3.0 FLIGHT TEST SUPPORT AND RESULTS

All hardware was shipped to Holloman AFB, N.M. on 13 June 1979 in support of a flight test which occurred on 28 June 1979. HYCOR technical field support was provided prior to and after test.

The preliminary test results indicate that all (6) canisters ejected properly, however, only (3) were observed to function by the T.V. camera mounted on the balloon. These units provided a large instantaneous smoke puff. A detailed

Table 1

HASP HEATER TEST
WITH STYROFOAM CASE

6/6/79

TIME	Q.C. BATT.	CURRENT DRAW	CHAMBER TEMP. ^{o}F	TUBE TEMP. ^{o}F						ELECTRICAL PLATE TEMP.	BATTERY COMPARTMENT TEMPERATURE
				1	2	3	4	5 1)	6	7	8
0815	29.8	0	+70°F	80	78	78	78	78	78	78	78
0900	29.7	0	-48°F	78	78	78	78	78	78	73	73
1000	29.7	0	-70°F	68	68	68	67	68	67	57	62
1100	29.7	0	-70°F	58	59	58	58	59	58	48	54
1200	29.7	0	-70°F	48	48	48	48	48	48	38	47
1300	29.6	0	-70°F	43	44	43	43	34	43	28	33
[illegible]	29.6	2)	-72°F	42	42	40	42	28	40	22	28
1500	29.6	2)	-70°F	42	42	41	42	25	41	20	23
1600	29.5	2)	-72°F	40	41	40	41	20	40	17	19
1700	29.5	2)	-70°F	40	40	40	41	18	40	14	17

1) Tube 5 Heater Switch Left Open.

2) Intermittent Current Draw.

Table 2

HASP HEATER TEST
W/O STYROFOAM CASE

6/7/79

TIME	QC BATT. VOLTAGE	CURRENT DRAW	CHAMBER TEMP.	TUBE TEMP.						ELECTRICAL PLATE TEMP.	
			CHAMBER COUPLE	1	2	3	4	5	6		
8:52A	29.7	0	-25°F	+73	+73	+73	+73	+73	+73	+50°F	
9:49	26.2	1.4 1)	-70°F	+44	46	45	45	45	44	-30°F	
10:45	25.6	1.4 1)	-72°F	35	39	40	40	40	38	-42°F	
11:00	25.0	1.4 1)	-70°F	33	38	39	40	40	38	-42°F	
11:45	25.2	1.4 1)	-71°F	31	37	37	38	38	36	-44°F	

1) Current Draw not continuous, individual heaters could be seen going on and off.

6/8/79

Table 3

HASP FUNCTIONAL COLD TEST

- Conditioner Box on at 0700
- Conditioner Box on at 0800 - $-70^{\circ}F$
- HASP Removed at 1500 - $-70^{\circ}F$
- HASP Functioned at 1535
- All Units Functioned Properly on 50 Ft. Lanyards From Height of 70 Ft.
- Cable Cutter Functioned and Lanyards Pulled Free by Hand.
- Total Battery Draw for Test 8 Amp Hours out of $+70^{\circ}F$ Capacity of 80 Amp Hours
$0^{\circ}F$ Capacity of 60 Amp Hours

examination of the T.V. film clearly showed all (6) canisters ejecting with proper lanyard deployment. However, in three (cases), no smoke puff was observed. In at least one case, it was felt that specular flashes of sun glint could be seen reflecting off an unopened, tumbling canister. Also, in several instances, severe lanyard lash-back with subsequent entanglement with previous lanyards and the recovery parachute shroud lines were observed. For this reason and although the cable cutter worked properly, the lanyard lines were recovered with the parachute. At least four (4) pulled pins were still attached to the lanyards with possibly more present but unfortunately a complete inspection was not performed. The presence of more than three (3) pulled pins does, however, point to the possibility of the canister spring-loaded pinger not operating properly or a failure of the glass to disintegrate properly. The spring-loaded pinger is restrained by the pin in a hole treated with dry-lube prior to launch. The frangible glass canisters have never failed to frange in thousands of tests conducted to date.

4.0 CONCLUSIONS AND RECOMMENDATIONS

Based on the results described above, it is concluded that, the HASP System provides a simple and low-cost technique for obtaining high altitude data in support of stratospheric turbulence studies. Clearly, an unknown failure mechanism associated with the lanyard/canister initiation system exists which either fails to pull the pin in every case or causes a sporadic failure in the initiation system. This failure mechanism has to be associated with the high altitude environment since no such failures occurred in the ground test program.

It is recommended that the current lanyard/initiation system be eliminated and replaced by either a squib eject and pyrotechnic delay mechanism to initiate canister opening or a reel-down type system with electrical initiation of canister opening be incorporated in furute HASP systems. The latter technique would maintain the 100 ± 5 foot requirement while the former would not.